

**STRUGGLING TO BE BORN:  
THE SCIENTIFIC COMMUNITY IN BRAZIL**

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# Struggling to be Born: The Scientific Community in Brazil

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BRAZIL is a newcomer to the worlds of both science and higher education. The country's first professional schools in law and medicine date from the nineteenth century, its first university was established in 1920, and, with a few exceptions, science as an organised activity barely existed before the 1930s. Movement has been rapid since then.

Enrolment in the institutions of higher learning in Brazil increased from 212,000 in 1968 to an estimated figure of more than 1.1 million in 1977<sup>1</sup>; today Brazil has about 60 universities and 800 separate institutions of higher education. Before 1965, only the University of São Paulo and a few other places offered some kind of graduate training, and only for a small number of students. Today, there are about 600 graduate programmes in about 30 universities and independent institutions throughout the country. Two thirds of these programmes lead to master's degrees, and one third to doctoral degrees. The University of São Paulo alone offered, in 1977, 103 M.A. and 66 doctoral programmes in all fields of knowledge. The quality varies; only one third of the doctoral programmes are considered academically good, and more than half of those are at the University of São Paulo.<sup>2</sup>

Since the first basic plan for the development of science and technology for the years 1973 and 1974 published by the government, the amount of resources allocated for scientific and technological development has been increasing progressively. The plan for the period from 1975 to 1977 projected a total of almost a billion dollars a year for expenditures in that field.<sup>3</sup> This total includes only a small fraction of the ambitious atomic energy programme which Brazil contracted for with the Federal German Republic in 1975, which is expected to cost about 10 billion dollars in 15 years.<sup>4</sup> The number of graduate students trained abroad on governmentally supported fellowships has increased

<sup>1</sup> Data supplied by Brazil, Ministério da Educação e Cultura, Serviço de Estatísticas da Educação e Cultura, Rio de Janeiro. The figure for 1977 is a projection.

<sup>2</sup> Brazil, Ministério da Educação e Cultura, Departamento de Assuntos Universitários, Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (DAU/CAPES), *Situação Atual da Pós-Graduação no Brasil* (Brasília: Ministério da Educação e Cultura, 1975).

Data for 1977 are from Brazilian governmental sources, still unpublished. Figures on academic quality of graduate programmes are based on periodic evaluations by peers under the sponsorship of the Ministry of Education.

<sup>3</sup> Brazil, Presidência da República, *Il Plano Básico de Desenvolvimento Científico e Tecnológico* (Brasília: Presidência da República, 1975).

<sup>4</sup> For a description and critical evaluation of this programme, see Gall, Norman, "Atoms for Brazil, Dangers for All", *Foreign Policy*, XXXIII (Summer 1976), pp. 155-201; and Lowrance, William W., "Nuclear Futures for Sale: To Brazil from West Germany, 1975", *International Security*, I (Fall 1976), pp. 147-166.

to about 2,000 annually. These students usually leave the country with an agreement to return to a university or research institution; they usually do so.<sup>5</sup> The scientific community has acquired an unprecedented prestige: the meeting of the Sociedade Brasileira para o Progresso da Ciencia is now one of the most important cultural, intellectual, and political events of the annual calendar.

The scientific and institutional developments of the present were initiated by a generation of scientists who took their degrees in the 1930s and 1940s, when the present Brazilian university system was being shaped. This formative period developed from Brazil's historical heritage.<sup>6</sup>

### *Enlightenment and Positivism*

Unlike the Spaniards, who attempted to implant in the new continent their administrative, cultural, and religious institutions and beliefs, the Portuguese only allowed for the creation of those institutions which were indispensable for the attainment of their economic objectives. In colonial times, the main educational establishments were Jesuit colleges. Unlike Spanish America, Brazil did not have a complete university until the twentieth century.

Brazil's colonial status ended in 1808 when the country became a "united kingdom" with Portugal; formal independence dates from 1822. British influence in Brazilian foreign trade and foreign policy was dominant from then until at least the First World War.<sup>7</sup> At the same time, the presence of the Portuguese court in America, as a result of the flight of the royal family to Rio de Janeiro in 1808 in order to escape Napoleon's army, meant that for the first time in its history Brazil was granted the right to have a few institutions of higher learning and technological training. In rapid succession, courses of medicine were organised in Bahia and Rio de Janeiro, a botanical garden was created in Rio, together with a national library, military academy, and museum. These institutions, along with the schools of São Paulo and Recife founded in 1827, were the only ones to offer some opportunities for scientific work and higher education in Brazil until the last decades of the nineteenth century.

<sup>5</sup> Mostly with fellowships from the Ministry of Education and of the Conselho Nacional de Pesquisas. For the patterns of study abroad and the return of Brazilian graduate students, see Schwartzman, Simon, *Projeto Retorno: Avaliação do Impacto do Treinamento, no Exterior, de Pessoal Qualificado* (Rio: Instituto Brasileiro de Relações Internacionais, 1972). For a comparative view, see Glaser, William A., *The Brain Drain: Emigration and Return* (Elmsford, N.Y.: Pergamon Press, 1978).

<sup>6</sup> See Schwartzman, Simon, *Formação da Comunidade Científica no Brasil* (Rio de Janeiro: Cia. Editora Nacional/Finep, 1979).

<sup>7</sup> See Manchester, Alan K., *British Pre-Eminence in Brazil: Its Rise and Decline* (Chapel Hill: University of North Carolina Press, 1933); and "The Transfer of the Portuguese Court to Rio de Janeiro", in Keith, H. H. and Edwards, S. F. (eds.), *Conflict and Continuity in Brazilian History* (Columbia, South Carolina: University of South Carolina Press, 1969). See also Graham, Richard, *Britain and the Onset of Modernization in Brazil, 1850-1914* (Cambridge: Cambridge University Press, 1968).

These first technical establishments were the heirs of the Portuguese Reforma Pombalina, which had been introduced in the University of Coimbra in 1772 by Dom Jose I's prime minister, the Marquis de Pombal. The Portuguese upper classes sent their offspring to Coimbra for the educational and professional qualifications which they needed for access to high positions in public life. Coimbra was also the place where, up to the middle of the nineteenth century, the upper classes of Brazil sent their sons to study in the schools of law and medicine.<sup>8</sup> Pombal's reform was an earnest effort to modernise the university and to bring Portugal abreast of Europe in economic, technological and cultural matters. Under Pombal, the Jesuits were expelled from the Portuguese empire, the teaching of scholastic philosophy was banned, and the University of Coimbra was enriched by a school of mathematics and natural philosophy, laboratories of chemistry, physics, pharmacy, and anatomy, and the arrival of foreign teachers, mostly Italian.<sup>9</sup>

The established Roman Catholic church resisted the rationalistic reform which would undo the order in which the state was under ecclesiastical dominion. Pombal's reform sought to free the state from the authority of the church while maintaining an authoritarian and centralised political system. The introduction of modern science into Portuguese culture was essentially a political and administrative act, a kind of "revolution from above", and it encountered resistance. Portugal did not experience the spontaneous growth of scientific activities and institutions which was so characteristic of Italy, France or England, from the sixteenth to the eighteenth centuries. There was no scientific community within which science could grow. The purpose of the reform was primarily practical and it made no provision for free experimentation, speculation, and research. If in the previous period instruction was based on the minute regulations of the Jesuit *ratio studiorum*, now the Pombal government prescribed the detailed application of the principles of science to the teaching of medicine, engineering, or geology. The drive to bring Portugal up to the level of the more advanced countries of Europe was the work of a secular political and administrative elite, which attributed Portuguese backwardness to the Roman Catholic church and its control of educational and cultural institutions.<sup>10</sup>

<sup>8</sup> On the education of the Brazilian elites in the nineteenth century, see de Carvalho, Jose Murilo, "Elite and State-Building in Imperial Brazil," unpublished Ph.D. dissertation, Stanford University, 1974.

<sup>9</sup> Cidade, Hernani, "A Reforma Pombalina da Instrução", in *Lições de Cultura e Literatura Portuguesa*, vol. II (Coimbra: Coimbra University, 1969); Dominques, Mario, *O Marquês de Pombal e Sua Época* (Lisbon: Romano Torres, 1963). See also Saraiva, Antonio Jose, *História da Cultura em Portugal* (Lisbon: Editora Jornal do Foro, 1955), and *A Inquisição Portuguesa* (Lisbon: Publicações Europa América, 1956).

<sup>10</sup> At the time of Pombal's reform, a short-lived *sociedade científica* was established in Rio de Janeiro, under the sponsorship of the Viceroy, Marquis de Lavradio, which dealt, among other things, with questions of production of a marketable dye, cochineal. See Azevedo, Moreira de, "Sociedades Fundadas no Brasil desde os tempos coloniais até o

Brazilian anti-clericalism drew much inspiration from France. France also provided the cultural ideal for the Brazilian Catholics; French conservative writers were very influential,<sup>11</sup> and French priests and nuns provided schools for the children of the country's best families. Brazil, in a way, translated the French social, political, and cultural cleavages into its own idiom. The French cultural influence was much more important in Brazil than the British, despite the much stronger economic presence of Great Britain in the country. In fact, since the early eighteenth century Portugal had been economically dependent on Great Britain and was under British political influence. This close relationship with Great Britain did not extend to the cultural and intellectual sphere. The Counter Reformation, the Inquisition, and the militancy of the Jesuit congregation kept the country isolated from the liberal ideas of the European enlightenment.

The French drive to build a modern, efficient and centralised state after the Revolution was much more meaningful for the Brazilian elite as a model of society than Britain, so deeply involved in the developments of its industrial revolution. French social and political thinking, rather than British economics, seemed to provide the answers the Brazilians wanted.<sup>12</sup>

France and, in a lesser degree, Belgium, replaced Portugal as the country where Brazilian students went to study and to acquire modern ideas.<sup>13</sup> In spite of the church's stern opposition, Freemasonry flourished among the elite, and Comtian positivism became its preferred doctrine.

### *The Influence of Positivism*

Positivism was taken more seriously in Brazil than practically anywhere else. Even at the end of the nineteenth century, most of the teachers of the Escola Politécnica in Rio were positivists, as were those of the Escola de Medicina. Comtian positivism was pervasive in the Brazilian army, and was the outlook of a substantial part of the political leadership in the states of Rio de Janeiro and Rio Grande do Sul, who were so active in the establishment of a republic in 1889. A positivist church—Igreja Positivista—was established in the country, and its leaders regularly

começo do atual Reinado", *Revista do Instituto Histórico e Geográfico do Brasil*, LXVIII, 2 (1885); Marchant, Alexander, "Aspects of the Enlightenment" in Whitaker, Arthur P. (ed.), *Latin America and the Enlightenment* (Ithaca: Cornell University Press, 1961); and Auden, Dauril, *Royal Government in Colonial Brazil* (Berkeley: University of California Press, 1968), pp. 376 ff.

<sup>11</sup> See Iglésias, Francisco, "Estudo sobre o Pensamento de Jackson de Figueiredo", in Iglésias, Francisco (ed.), *História e Ideologia* (São Paulo: Perspectiva, 1971), pp. 109-158.

<sup>12</sup> For an account of the British influence through the spread of Spencerian evolution, see the chapter on "Progress and Spencer" in Graham, R., *op. cit.* See also Morse, Richard M., "A Economia de Manchester e a Sociologia de São Paulo", *Dados*, 18 (1978), pp. 33-56.

<sup>13</sup> On the Brazilian students in Belgian technical schools, see Stols, Eddy, "Les Étudiants brésiliens en Belgique: 1817-1914", *Revista de História*, L, 100 (1974), pp. 653-692. No similar study of Brazilians in France seems to exist.

corresponded with Emile Littré, in Paris, about questions of positivistic orthodoxy.<sup>14</sup>

To understand how European liberal ideas were received in Brazil, one should bear in mind that until late in the nineteenth century, it had an agricultural economy based on slavery with only a few urban centres—Rio de Janeiro, Salvador da Bahia, Recife, Porto Alegre—where there was some political, cultural, and intellectual activity. Neither liberalism, republicanism, evolutionism, nor positivism kept in Brazil the meaning they originally had. In Europe they were part of a political and intellectual process which gave rise to new professional, business and working-class groups. In Brazil, they were banners used in political conflicts which shifted leadership from the north to the south, from the landed aristocrats to the urban bureaucrats, from civilians to the military, from the old to the new generations, in a society which remained strongly stratified and, for a long time, immune to deeper social changes.

Comtian positivism provided the civilian leadership with an outlook very much like Pombal's. Both were anti-clerical; both were utilitarian and authoritarian. Each had its own orthodoxy and neither left room for free speculation. They both favoured technical and applied knowledge over experimental and theoretical science. Although Comtian positivism in Brazil was republican, it was also authoritarian and aimed at social progress through an enlightened oligarchy. The espousal of Comtian positivism conferred on its exponents a sense of being modern, of being in favour of science and oriented towards the future, and it distinguished them from those obscurantists who thought that the ideal resided in the past.

Comtian positivism was nonetheless not conducive to scientific investigation. Positivists were against the universities, they called them "pedantocracies" and had no use for them. Since Comte had already arrived at the definitive synthesis, the cosmos of knowledge was viewed as closed, with no room for new theories, concepts or research. Teaching in the professional schools of nineteenth-century Brazil was usually a dogmatic, formalistic exercise, based on old textbooks of poor quality, and the positivistic rhetoric which suffused it seldom improved its quality. The lack of competition among the different schools, the absence of a scientific and technological tradition of amateur investigators who could set higher standards, the limited demands for technical skills placed by society upon its doctors and engineers, all these factors help to explain this state of affairs. What was absorbed from Europe was a new form of belief, not curiosity or a discriminating sense of quality. Neither the

<sup>14</sup> On Brazilian positivism, see Costa, João Cruz, *Contribuição à História das Idéias Filosóficas no Brasil* (Rio de Janeiro: José Olímpio, 1956), and *O Positivismo na República* (São Paulo: Editora Nacional, 1956); Lins, Ivan M., *História do Positivismo no Brasil* (São Paulo: Editora Nacional, 1964); and Paim, Antonio, *História das Idéias Filosóficas no Brasil* (São Paulo: Grijalbo, 1974).

establishment of science in Portugal by decree of the Reforma Pombalina nor the imported Comtian positivism was a substitute for a body of active scientists. This was lacking in Brazil.

### *Early Scientific Institutions*

As contacts with Europe, and later the United States, increased, so did the flow of new ideas. Orientations and standards of work also changed. One important element in keeping these contacts open was Pedro II, the Brazilian emperor from 1840 to 1889. He was an enthusiastic supporter of modern technology, and brought foreign scientists to the country to help establish research institutions. He was, for instance, directly responsible for establishing the Escola de Minas in Ouro Preto, based on the French model and under a French director, Henri Gorceix; he organised the Observatório Nacional, also directed by a Frenchman. The Emperor established several of the research laboratories of the Museu Nacional and he was always willing to cooperate with foreign scientific expeditions.<sup>15</sup>

The list of foreign scientific expeditions in nineteenth-century Brazil is large, and includes some important names: von Langsdorff from Russia; Auguste de Saint-Hilaire from France; von Eschwege, von Spix, von Martius, from Germany and Austria; Alfred Wallace, Henry Bates, and Darwin himself, from England; and the Thayer expedition from the United States which brought Louis Agassiz and his collaborators; some of these, like Charles Hartt and, most important, Orville A. Derby, remained in Brazil. Hartt later organised the Comissão Geológica Imperial in 1875; Derby established the Comissão Geológica e Geográfica of São Paulo in 1886, and became the most pre-eminent scientist in Brazil in the earth-sciences. Other foreign scientists working in Brazil during the 1880s and 1890s included Fritz Müller, who contributed to the empirical consolidation of the theory of evolution; Emile Goeldi, organiser of the Museu de História Natural of Pará, in the Amazon region (1893); Herman von Ihering, organiser of the Museu de História Natural of São Paulo (1893); Louis Couty, who worked with J. Batista Lacerda in the laboratory of experimental physiology of the Museu Nacional in Rio; F. W. Dafert, who organised the agronomic station of Campinas, São Paulo, as the first agricultural research centre in the country (1887). These early institutions provided Brazil with an incipient scientific community. Their support, however, came from the Emperor's enlightened outlook, rather than

<sup>15</sup> The most comprehensive source for specific information on different scientific fields in nineteenth-century Brazil are the articles published by Azevedo, Fernando de, *As Ciências no Brasil* (São Paulo: Melhoramentos, 1953 (?)). For the school of mines in Ouro Preto, see Carvalho, Jose Murilo de, *A Escola de Minas de Ouro Preto: Crespúculo de uma grande obra?* (Rio de Janeiro: Editora Nacional/Finep, 1978).

from interested Brazilian scientists. As the empire fell, most of these institutions lost their impetus and their leaders.<sup>16</sup>

The shift of Brazil's economic and political centre from the north central to the south central part of the country—and most specially to the São Paulo area—was ultimately responsible for the demise of the imperial regime and the installation of the Federative Republic in 1889, one year after slavery was finally abolished.<sup>17</sup>

Profound changes occurred in many areas of activity, including science, technology, and higher education. There was a current of public opinion which carried the sense that the country was entering the new century as a modern society, to which science could bring its benefits.

The new, emerging social elite, which included the coffee growers in São Paulo, the military in Rio de Janeiro and Rio Grande do Sul, the lawyers, engineers and physicians educated in the schools of Rio, São Paulo, France and Belgium, had little sympathy with the scientific institutions organised under the empire and staffed by Europeans still attached to the academic communities of their countries. The imperial institutions decayed, and new ones were established throughout the country, mostly in São Paulo, with very practical goals. These included bacteriological institutes in Rio de Janeiro and São Paulo; agricultural research centres in São Paulo; schools of engineering, pharmacy, and veterinary medicine in São Paulo, Porto Alegre and Rio de Janeiro; and state and national meteorological and geological services.

### *Scientific Institutions and Applied Research*

A dramatic demonstration of the immediate benefits which science could bring was given by the spectacular results of the work against malaria, yellow fever, and other contagious diseases. The drive was organised by the bacteriological institutes of Rio and São Paulo, established in 1892 and 1900.<sup>18</sup> Adolpho Lutz, born in Brazil and trained in Europe,

<sup>16</sup> Summary descriptions of the activities of the naturalists in nineteenth-century Brazil can be found in Rowe, James W., "Science and Politics in Brazil: Background of the 1967 Debate on Nuclear Energy Policy", in Silvert, Kalman E. (ed.), *The Social Reality of Scientific Myth* (New York: American Universities Field Staff, 1969), pp. 91–122; and Stepan, Nancy, *Beginnings of Brazilian Sciences: Oswaldo Cruz, Medical Research and Policy* (New York: Science History Publication, 1976).

<sup>17</sup> On the cleavages between the São Paulo area and the country's political centre, which remained in Rio, see Schwartzman, Simon, *São Paulo e o Estado Nacional* (São Paulo: Difel, 1975).

<sup>18</sup> The Brazilian literature on the bacteriological institutes is extensive and some materials are also starting to appear in English. The most complete set of documents about the Instituto Oswaldo Cruz (or Manguinhos, as it was first called) is contained in Falcão, Edgar Cerqueira, *Oswaldo Cruz, Monumenta Historica*, 3 vols. (São Paulo, 1973), the second volume of which contains an historical narration by one of the Instituto's scientists, Olympio da Fonseca Filho. See also Blount, J., "The Public Health Movement in São Paulo, Brasil—A History of the Sanitary Service, 1892–1918", unpublished Ph.D. dissertation, University of Michigan, 1975; Pena, M. V. Junho, *A Evolução da Pesquisa em Saúde no Brasil: Uma Interpretação Preliminar* (Rio de Janeiro: Conselho Nacional de Desenvolvimento Científico e Tecnológico, mimeographed, 1977); Stepan, N., *op. cit.*, and the review by Ben-David, Joseph, "The Implantation of the Scientific Tradition in Developing Countries", *Minerva* XV, 1 (Spring 1977), pp. 102–105.



started his work in São Paulo; it was later taken up at a national level by the Instituto Oswaldo Cruz in Rio de Janeiro. In a few years, effective sanitary arrangements in Rio de Janeiro and other areas had been completed, and the prestige of the scientists' achievements was established in Brazilian society.

The close contacts between the Instituto Oswaldo Cruz and the Institut Louis Pasteur, where Oswaldo Cruz himself was trained, the international acknowledgement received by the work of the Instituto, and the freedom of movement brought by their successes in the country—all these factors helped the Instituto become a scientific centre, which placed pure research at its core, but from which practical applications were supposed to flow. This attempt did not succeed in São Paulo, where the pressure for strictly practical activities finally prevailed. In the first decade of this century the Instituto in Rio de Janeiro came to the fore as the main scientific research institution in the country.

After about 15 or 20 years, the international prestige attached to the Instituto's initial achievement faded away, but its domestic prestige lasted much longer. In this situation, there was little incentive to keep alive the ties of correspondence, meetings and interest with foreign institutions. In the ensuing years, a cleavage developed within the Instituto between those who had entered upon a vocation devoted to research in the early years and those who thought that their first task was to attend the short-term demands of the health authorities, to whom the Instituto was subordinated. Without the stimulus of new challenges and academic competition, the Instituto gradually fell under the sway of routine and bureaucracy; in addition, the introduction of the sulfa drugs in the 1930s rendered much of its practical work in the area of preventive medicine superfluous. An increasingly centralising national bureaucracy reduced still further the flexibility and freedom of decision which the Instituto had enjoyed in the previous years. In spite of all these problems, the Instituto Oswaldo Cruz was, up to the 1930s, the only place in Brazil where training in biomedical research was available. Most of the best Brazilian workers in this field at the time were trained there.

Other attempts to implant and instil scientific traditions from work on practical tasks were less successful. The Brazilian geographical and geological commissions, organised by Orville Derby in the 1890s as institutions for scientific research, became unproductive, bureaucratic organisations. Some success, however, was achieved in several institutions related to the Instituto Oswaldo Cruz in the São Paulo area; the Instituto Butantan became famous for its work on snake venom, and the Instituto Biológico, directed by Henrique da Rocha Lima, who had been trained in Germany, had an early success with the control of a blight in the coffee plantations.<sup>19</sup>

<sup>19</sup> Rocha e Silva, Mauricio, "Birth and Development of Experimental Science in Brazil", *Interciencia*, I, 4 (November–December 1976), pp. 215–217.

The early history of the Instituto Agronômico de Campinas is a good example of the difficulty of developing a scientific tradition from institutions created primarily for the sake of practical results. At the turn of the century, São Paulo was the centre of an expanding coffee economy, based on practically unlimited land, cheap labour and a virtual monopoly in the world's coffee trade. In this context, agronomic research for the improvement of species or better use of soil was not necessary economically. Research on other agricultural products was for the same reason thought to be a waste of time and money. The first director of the Instituto Agronômico, F. W. Dafert, an Austrian chemist, returned after some years to Vienna to become the head of an experimental research station in agricultural chemistry, having failed in his efforts to convince the *paulistas* of the utility of his work.

The Instituto Biológico, established in 1927, was fortunate in attaining one striking success, which was the identification and control of the coffee *broca* (*Hypothenemus Hampei*), a very destructive blight which was injuring the plantations. The ability of its scientists to build a successful research centre on the basis of this one stroke of good fortune resembled the way in which the Instituto Oswaldo Cruz had been created almost 30 years before. The fact that these biologists had been part of the tradition founded by Oswaldo Cruz in biological research was also very important since they had a model to follow.

In the absence of developed industries, well-trained chemists were not in demand; the university system, concerned with training for the professions, would not give hospitality to independent research in chemistry. Between 1910 and 1930, several German scientists were invited to establish courses of chemistry in Minas Gerais, Porto Alegre, and Rio de Janeiro, but without significant results.

The situation was somewhat better in the fields of chemistry related to medical and pharmacological research, such as the group headed by J. Baeta Viana at the school of medicine in Belo Horizonte and the groups at the Instituto Butantan and Instituto Biológico in São Paulo, which were supported by their respective state governments.<sup>20</sup>

Another example of the relationships between pure and applied science may be seen in the history of the Observatório Astronômico Nacional. Established as a section of the Escola Militar do Rio de Janeiro in 1827, its work did not really get under way until 1850, when the first instruments were obtained, and routine observations began. In 1870, its direction was given to Emmanuel Liais, a French astronomer who had previously worked in the Paris Observatoire and who had been invited by Pedro II to join the expeditions for the observation of the solar eclipse of 1858.

<sup>20</sup> For the history of chemistry in Brazil, see Rheimboldt, R., "A Química no Brasil", in Azevedo, Fernando de, *As Ciências no Brasil* (São Paulo: Melhoramentos, c. 1955), vol. II, pp. 11-89; and Mathias, Simão, *Cem Anos de Química no Brasil* (São Paulo: Coleção da Revista de História, 1975).

With Liais, the Observatório became independent of the Escola Militar, more advanced equipment was brought from Paris for studies of the orbit of planets and comets and for the development of a precision chart of Brazil. The latter work had the cooperation of a Belgian astronomer, Louis Cruls, who succeeded Liais in 1881. Upon his death, in 1908, the post was taken by Henrique Morize, also French by birth, but educated in Rio de Janeiro; he headed the Observatório until 1930.<sup>21</sup>

The tradition of research started by Liais was never understood by the Brazilian public. In the less specialised public, astronomical studies tended to be identified with the popularised, romantic image given to it by the popular works of the French astronomer, Camille Flammarion; or to be considered as a wholly practical activity having to do with meteorological observations and the determination of time and distance. The latter finally prevailed, and in 1909 the Observatório was placed under the Ministry of Agriculture, in a section of meteorology and astronomy. The strategy of Morize was to develop an efficient system of meteorological observation, which would give him sufficient freedom to continue his astronomical research.<sup>22</sup>

The historical importance of Henrique Morize was not limited to his achievements in astronomy. He was professor of general and experimental physics at the Escola Politécnica of Rio de Janeiro, which had grown out of the old military academy. His thesis, submitted in 1896, to the Escola Politécnica, was on cathodes and X-rays. He was the founder of the Sociedade Brasileira de Ciências in 1916, which later became the Academia Brasileira de Ciências, and he presided over the academy for its first 10 years. Together with Otto de Alencar, a mathematician who had been teaching at the Escola Politécnica since 1902, he challenged the intellectual supremacy of the Comtian positivists at the school, and he helped foster a movement in support of science and universities as intellectual institutions which was influential in the country for many years.

### *The Challenge to Positivism and the Movements for Science and Education*

Positivism was not only a general scientific outlook among Brazilian intellectuals and politicians; it also influenced the contents of the courses and technical training provided by the military and engineering schools. Comtian orthodoxy was considered the ultimate standard of mathematical proof, and it established external limits to what the mathematicians could attempt to do. The more talented students of the Escola Politécnica in Rio de Janeiro read with excitement and an air of conspiracy the

<sup>21</sup> For the history of astronomy in Brazil, see Morais, Abrão de, "A Astronomia no Brasil" in Azevedo, F. de, *op. cit.*, vol. I, pp. 81-162.

<sup>22</sup> This description is based on an unpublished manuscript by Lelio Gama, a Brazilian mathematician and former director of the National Observatory.

imported French books which contained the more recent advances in mathematics and physics. In a series of articles published in France, Portugal and Brazil, Otto de Alencar exposed the mathematical inconsistencies of Comte, and showed how he tried to stop the development of the discipline, by ruling out as "metaphysical" such topics as the theory of numbers, the theory of probability, and the calculus of elliptic and discontinuous functions. In Europe, mathematics advanced and Comte's ideas were not even considered in the institutions in which mathematics was regarded seriously. In Brazil, however, the debate between modern and positivist mathematics was a long one. In 1925, on the occasion of Albert Einstein's visit to Brazil, the professor of rational mechanics at the Escola Politécnica, Licínio Cardoso, published an article called "Imaginary Relativity". By then, positivism had been defeated as a philosophy of science; its political and social influence, however, remained.<sup>23</sup>

The Sociedade Brasileira de Ciências was the first attempt in the history of Brazil to argue publicly that scientific research should be provided with adequate institutions. It emerged in close collaboration with the Instituto Franco-Brasileiro de Alta Cultura, and started the publication of a journal of sciences. In 1922, it became the Academia Brasileira de Ciências; it actively promoted scientific values, and held conferences featuring well-known European scientists.

More active and vocal than the Academia was the Associação Brasileira de Educação. It was created as a voluntary association of scientists, educators and intellectuals, and its leadership overlapped with that of the Academia. It promoted conferences, debates, seminars and publications in the country about the issues of modern education and science. After 1927, it organised several "surveys" of opinion in the educated class about the educational needs of the country, and it also held several national conferences on education, which had some influence.<sup>24</sup>

The Associação was a heterogeneous group, aiming to be a forum for the discussion of educational issues rather than to contend for a particular view. In time, some more substantive aims crystallised. In general education, the dominant figure was Anísio Teixeira, who brought to Brazil the ideas of mass public education and modern pedagogical methods; he was influenced by William James and John Dewey. A conflict with the church was unavoidable. Teixeira and his followers were denounced as communists and atheists; nevertheless they did help to shape the educational system. In higher education,

<sup>23</sup> For a detailed account, see Ribeiro, J. Costa, "A Física no Brasil" in Azevedo, F. de, *op. cit.*, pp. 168-169; and the introductory essay by Paim, Antonio, "O Neopositivismo no Brasil: Período de Formação da Corrente", in Costa, Amoroso, *Idéias Fundamentais da Matemática* (São Paulo: Gríjalbo, 1971).

<sup>24</sup> For a detailed account of these developments, see Paim, Antonio, "A Universidade do Distrito Federal e a Formação da Universidade do Rio de Janeiro", in Schwartzman, S. (org.), *Universidades e Instituições Científicas no Rio de Janeiro* (forthcoming).

genuine leadership was provided by this group which also belonged to the Academia. They all agreed that a university should be established in the country which would recognise the principle of academic autonomy, be organised around a school of sciences, and maintain a clear distinction between training for the professions and scientific research. The University of Brazil, which was established in 1920 by bringing under one name the independent, unco-ordinated professional schools, was not thought to meet these requirements.

### *Science, Education and the Estado Novo*

The fate of these movements for public education and for a new university should be seen in the light of the deep social and political changes in Brazilian society at the time. Several decades of a booming coffee economy provided the basis for an incipient industrialisation which gathered momentum in the 1930s. A large European migration—from Italy, Germany, Spain and Portugal—brought new values, outlooks and political ideologies which challenged the traditional leadership of the country.

The 1920s were the last decade of the old regime. The *República Velha*, had placed most political decisions in the hands of small provincial oligarchies and old-fashioned military officers. Dissatisfaction was widespread among young officers, intellectuals and the emerging business class of São Paulo.

In 1930 a new regime was established, headed by Getúlio Vargas, who became the country's leading figure for the next 25 years. One basic feature of this new regime was that it excluded from the national government not only a substantial part of the old oligarchies, but also the new economic, political and intellectual leaders of the state of São Paulo, which was already becoming the centre of the country's economy.<sup>25</sup>

The Vargas regime progressively institutionalised an authoritarian state built on the republican and positivistic political traditions of Rio Grande do Sul. The positivist outlook legitimated a powerful civilian oligarchy linked to the military which aimed to modernise the country. The new regime took over many of the ideas developed by the Associação Brasileira de Educação. The national conferences of education were supported by the state, and some of the leaders of the movement were called upon to reform the educational systems of the largest cities. Anísio Teixeira became the secretary of public instruction of the Federal District of Rio de Janeiro between 1932 and 1935. Fernando de Azevedo, another active member of the group, had been previously in charge of the educational reform in Rio de Janeiro, and after the insurrection of 1932 the secretary for education in the state of São Paulo. Later on, an

<sup>25</sup> See Dean, Warren E., *The Industrialization of São Paulo* (Austin: University of Texas Press, 1969); and Schwartzman, S., *op. cit.*, 1975.

important sector of the Associação Brasileira de Educação was incorporated into the Ministério da Educação as the Instituto Nacional de Estudos Pedagógicos, under the direction of another of the leaders of the movement, Lourenço Filho.

The group of intellectuals involved in the educational and university reforms at the time was a surprising mixture of liberal and fascist beliefs and personalities. Side by side with Anísio Teixeira was Francisco Campos—better known as the author of the authoritarian *carta constitucional* of 1937, which established the *Estado Novo*.<sup>26</sup> In 1931, Campos, as the Minister of Education, drew up a new university law. This was a law which, in principle, supported the creation of schools of science, the freedom of research and the establishment of university autonomy. In practice, however, it created a system of tight governmental control over the university; it represented a strictly utilitarian attitude. In the new institution, the school of sciences of the university in Rio de Janeiro was to begin as a school of education to train secondary-school teachers, and all university matters were minutely defined in advance.<sup>27</sup>

The most significant attempts to achieve the idea of a university in the 1930s were not results of this legislation, but reactions to it. The first was the short-lived Universidade do Distrito Federal, organised in Rio de Janeiro by members of the Associação Brasileira de Educação, under the leadership of Anísio Teixeira; it was frustrated. It had a Faculdade de Ciências which conformed with the national programme of preparing school teachers, but it also recruited several talented scientists, who started to do research. This university was dissolved during the repression which followed the attempted *coup d'état* by the communists in 1935, and some of its staff was absorbed by the Faculdade de Filosofia of the University of Brazil, which is now the Universidade do Rio de Janeiro. This institution, established in 1938, was never meant to be a centre for research, and did not have full-time teachers. An exception was the small group of physicists around Joaquim Costa Ribeiro, who, with Bernard Gross, was responsible for the formation of an outstanding group of scientists in solid-state physics. The Faculdade de Medicina also had some important research interests, pursued in the institute of biophysics.

### *The Universidade de São Paulo*

A more successful project was that developed in the state of São Paulo, following the unsuccessful uprising of the state against the federal

<sup>26</sup> On Francisco Campos's participation in the educational reform in Minas Gerais and his political career, see Wirth, John D., *Minas Gerais in the Brazilian Federation, 1889-1937* (Palo Alto: Stanford University Press, 1977). On Brazilian fascism in the 1930s, see Carone, Edgard, "Ação Integralista Brasileira", in *A República Nova: 1930-1937* (São Paulo: Difel, 1976), pp. 194-231.

<sup>27</sup> See the decrees number 19,850, 19,851 and 19,852 of 11 April, 1931. The full texts can be found in Lobo, Francisco Bruno, *Uma Universidade no Rio de Janeiro* (Rio de Janeiro: Universidade Federal do Rio de Janeiro, 1967 to 1969) 3 vols., vol. II, pp. 156-338.

government in 1932. The political marginality of the country's richest region led to a concerted effort to build a cultural and intellectual elite which would win for the state, in the long run, the political battle it was losing against the federal administration.

In 1933, an autonomous *Escola Livre de Sociologia e Política* was organised under the leadership of Roberto Simonsen, an industrialist and economic historian. It trained many of the state's future political and economic leaders in the modern social sciences, in contrast with the traditional law schools. The school of sociology was empirically oriented, and was intended to be a

center for social and political culture able to raise the interest for the common good, to establish the links between man and his environment, to stimulate research on the living conditions of our population, and to shape personalities which could cooperate efficiently and consciously in the direction of the country's social life.<sup>28</sup>

Its ties with the Smithsonian Institution and the Rockefeller Foundation helped; it introduced North American sociology into Brazil, in contrast with the French-oriented social sciences department of the University of São Paulo, which was established not long thereafter.<sup>29</sup>

The University of São Paulo was organised separately and with much wider aims in 1934. The heart of the new university was to be its *Faculdade de Filosofia, Ciências e Letras*. According to the national rules, it was supposed to train teachers for the secondary schools of the state. The recruitment of its staff was, however, done in such a way as to promote the development of independent scientific research. Its strategy was to attract a staff of well established foreign scientists, who could bring to Brazil knowledge and skill from their own intellectual traditions. They were expected to do their own research, train their students, and at the same time, help to improve the old professional schools in the state, now brought together in the university.

The recruitment of professors in the natural sciences was delegated to a mathematician, Teodoro Ramos, who had belonged to the group in Rio de Janeiro which had broken with positivism. He brought from Italy an outstanding group of mathematicians and physicists, including Gleb Wathagin, in physics, and Luigi Fantappiè, in mathematics, and, for a brief period, Giuseppe Occhialini. The Italian government considered this exchange an important cultural and political activity, and subsidised the salaries of the professors. Heinrich Reimboldt, formerly a professor at the University of Bonn, organised the chemistry department, in which he was shortly followed by Heinrich Hauptman, in organic chemistry. Paulo Duarte, a literary man and publicist, influenced the

<sup>28</sup> Berlink, Cyro and Ferrari, Alfonso Trujillo, *A Escola de Sociologia e Política de São Paulo (1933-1958)* (São Paulo: Escola de Sociologia e Política, 1958), pp. 10-11.

<sup>29</sup> Berlink, Cyro, *A Escola de Sociologia e Política de São Paulo (1935-1958)* (São Paulo: Escola Livre de Sociologia e Política, 1958).

recruitment of French social scientists. For different periods of time, Claude Lévi-Strauss, Roger Bastide, Pierre Monbeing, Paul-Arbusse Bastide, Fernand Braudel, and several others taught at the University of São Paulo in its first years, and helped to establish a tradition in the social sciences which became more influential than that developed by the Escola de Sociologia.

The effects of the new Faculdade de Filosofia, Ciências e Letras on the Brazilian scientific and cultural milieu are paradoxical. The experience was in many ways a failure: the professional schools did not allow its professors to teach their courses, very few students of high quality were attracted to scientific careers, and, when the governor, Armando de Salles Oliveira, lost political power a few years later, the federal government sought to bring the faculty under its own scrutiny.

At the same time, the experience of organising an independent and intellectually productive scientific institution was not lost. Almost all subsequent scientific work in Brazil over the next 20 years can be traced to the work of this original group, in both the natural and the social sciences. After the Second World War, the University of São Paulo was the only state-supported university in the country, where otherwise the federal government took responsibility for the universities. Although additional state universities were created, such as the University of Campinas, the University of the State of São Paulo and the University of Rio de Janeiro, it remained the most important teaching and research institution in the country. One indication of this is that, of 988 articles published by Brazilian scientists in internationally recognised journals in 1974, half were from institutions located in the state of São Paulo, and 234 were from the University of São Paulo alone. The second largest institution in the production of publications was the Federal University of Rio de Janeiro, with 84, followed by the Federal University of Minas Gerais. The University of Campinas, also in the State of São Paulo, was the highest on a per capita basis, followed closely by the other *paulista* establishments. Internationally, Brazil ranked 29th in 1974, after Israel, Spain, and Argentina (which was 28th), but ahead of Mexico (36th), Chile and Portugal (51st). Brazilian production of scientific papers increased more than four-fold from 1967 to 1974; its share of the world's scientific production increased from 0.163 to 0.308 per cent., which meant a modest advance from the 32nd to the 29th position.<sup>30</sup> The improvement has largely been the work of the state universities.

### *Post-war Developments*

The years since the Second World War may be divided into two very

<sup>30</sup> Data from *Who is Publishing in Science* (WIPIS), analysed by Morel, Regina Lucia M. and Morel, Carlos Medici, "Um Estudo Sobre a Produção Científica Brasileira segundo os Dados do Institute for Scientific Information", *Ciência da Informação*, VI, 2 (December 1978), pp. 99-109.



different periods and three fairly independent lines of development. The two periods are divided by the year 1968, when the new graduate programmes were created, the size of the undergraduate system expanded, and much more money was allocated to research. The lines of development were the growth and strengthening of the country's scientific community and its institutions, the increasing demands for professional training and the consequent expansion of the professional schools, and the participation of the federal government as an active agent in establishing a scientific and technological policy of its own.

The military participation of the country in the Second World War was not very large, but it provided the regime with a good reason to attempt the first programme of economic mobilisation and planning in the history of the country. Traditional patterns of trade were upset, but Brazil became a supplier of some important strategic materials for the Western allies—diamonds, manganese, nickel, tungsten, and more important, rubber. An important step in the industrialisation of the country was the establishment of the steel mill of Volta Redonda, which had the technical and economic support of the United States and was part of the agreements which brought Brazil into the war.<sup>31</sup> The reduction of imports increased the demand for São Paulo's manufactured products, and created a surplus of foreign currency. When the war ended, a constitutional government based on universal suffrage replaced the Vargas regime, and Brazil's economic surplus was used to create the beginnings of industries oriented towards mass consumption. Once the foreign currency reserves were depleted, Brazilian and foreign-owned industries started to produce for the demands of consumers in an expanding urban sector.

#### *Expansion of Professional Education*

These changes led to increased demand for professional training. Some of it arose from effective demand for engineers, doctors, lawyers, and teachers. Less recognised, but probably more important, was the desire of the middle classes for social prestige and the benefits brought by professional status. A university degree promised a certain level of social prestige and income regardless of the quality of the education received. Legal privileges for the holders of diplomas were established in time not only for the traditional professions—physicians, lawyers, and engineers—but also for new professions like economists, statisticians, administrators, journalists, and psychologists. In each case, a section of the market for employment is reserved for the holders of particular diplomas; there are also rules prescribing minimal rates of remuneration for the members of these privileged professions. Attempts to establish legal privileges for sociologists have failed so far.

<sup>31</sup> See McCann, Frank D., Jr., *The Brazilian-American Alliance, 1937-1945* (Princeton: Princeton University Press, 1973).

To meet the demand for degrees, a group of federal universities was established, which absorbed the old professional schools and state universities throughout the country and created new ones. Only São Paulo retained its state university. In addition, beginning in 1940, a national system of private, Catholic universities emerged in Rio de Janeiro, São Paulo, Porto Alegre, Recife, and Belo Horizonte. Private professional schools were permitted, and they grew up throughout the country, mostly in fields where technical equipment and specialised training of the staff were not essential. The federal universities were under the Ministry of Education and followed the general outlines of the legislation first proposed by Francisco Campos; governmental inspection and standardisation of syllabuses were extended to the private institutions. Teachers in federal universities were defined as civil servants, subject to uniform systems of payment and tenure. Although education was free, highly competitive entrance examinations restricted applicants. For those who failed, there were always the alternatives of employment with lower prestige or admission to private schools where the quality of education—and the prospects for subsequent employment—were inferior. Since secondary education in Brazil remained mostly private, it was the affluent who had access to a free university education, while others, lacking a good secondary training, had little chance to be admitted, or had to pay more for poorer alternatives.

These developments in the system of higher education did not make much provision for scientific training and independent research. Industrialisation of the country created opportunities for trained professionals in many fields. At the same time, however, the new industries imported their equipment and processes from foreign countries. There was little demand coming from industry for indigenous technological innovation; nor would the universities have been able to meet this demand had it existed. There was little demand for scientists or for technologists well grounded in science.

#### *The Growth of the Scientific Community*

Scientific research continued to develop in the institutions established before the war, mostly in the biological sciences. These included the Instituto Biológico de São Paulo, which inherited much of the tradition of the Instituto Oswaldo Cruz. In Rio de Janeiro, the Instituto de Biofísica of the Faculdade de Medicina of the Universidade do Rio de Janeiro became a centre of some international reputation. Two medical schools in São Paulo, the private Escola Paulista de Medicina and the Faculdade de Medicina of the Universidade de São Paulo, set new standards for medical studies in the country. Thanks to financial support and guidance by the Rockefeller Foundation, the American model of medical teaching was introduced at the Faculdade de Medicina, with the adoption of full-time employment, *numerus clausus* for admissions and close

cooperation with the Johns Hopkins University School of Hygiene and Public Health. The Rockefeller Foundation had been active in Brazil since the 1920s. Prior to the war, it worked mostly in the field of public health, not only in training Brazilians but in practical activity in the field as well. During the war, a programme of fellowships for Brazilian scientists was established by the Rockefeller Foundation, awarding fellowships on the basis of individual merit rather than by subject. This programme benefited scientists in physics, chemistry and genetics; research in medicine and agriculture was improved by this programme.

Agricultural research and genetics had been the concern of the Escola de Agricultura Luis de Queirós in São Paulo, which had been established at the turn of the century and incorporated in 1934 into the University of São Paulo. An important innovation after the war was the Instituto Tecnológico da Aeronáutica, in São José dos Campos, São Paulo, a civilian school of engineering established by the Brazilian Air Force in close cooperation with American institutions and following American models. This incomplete list shows that the Brazilian scientific community was mostly concentrated in one region, and at the margin of the large system of professional education which was being built by the federal government throughout the country.

In these few institutions—and in the most important of them all, the Faculdade de Filosofia, Ciências e Letras of the Universidade de São Paulo—the incipient Brazilian scientific community began to take form and to try to play an active role in national life.

The idea that science and education should have benefits for society was, of course, pervasive after the Second World War. Many Brazilian academics took this idea seriously and began to contend in public that action should be taken to bring learning to bear on practical problems and, as a means to this end, that action should be taken to improve higher education and the conditions of scientific research. Social scientists, for example, directed their writings to the larger public and not just to their professional colleagues. Others tried, sometimes simultaneously, to create new institutions and policies which would enable the country to strengthen its scientific and technological institutions. Roles as political reformers, governmental advisers and publicists seemed appropriate and necessary to many Brazilian scientists. Others, of course, always preferred a more specific and narrower role; but even for them, concern for the conditions for normal scientific activity implied some minimum of social and political participation.

As part of a movement led by scientists in the state of São Paulo to protect their research institutions against the populist politics of the governor of the state, Adhemar de Barros, the Sociedade Brasileira para o Progresso da Ciência was formed in 1949. For many years it was not widely known, but its role in the legitimation of scientific activity in

Brazil should not be disregarded.<sup>32</sup> More recently, it broadened its scope to include new fields, like the social sciences, and more scientists from other states besides São Paulo. It publishes a widely read journal, *Ciência e Cultura*, and thousands of scientists and students attend its annual meetings, which are reported in the media of mass communications. The agenda extends from the most esoteric scientific papers and the problems of scientific and technological policy to public lectures and round tables on social and political questions.

Another important development, also in São Paulo, was the creation of the Fundação de Amparo à Pesquisa in 1960, as established by the state constitution of 1946. This body receives 0.5 per cent. of all state tax revenues, for the support of scientific research projects. The resources are allocated by a director, who is a member of the São Paulo scientific community and who draws upon it for advice.

### *Research in Physics, Atomic Energy and Science Policy*

Research in physics began in São Paulo as pure science, but it was the ground for the establishment of the first institutions of national science policy in Rio de Janeiro.<sup>33</sup> Physics in São Paulo started with Gleb Wathagin, born in Russia and trained in Turin, where he worked in the field of cosmic rays during the 1920s. He witnessed the intense research activity in Europe, then developing around Bohr, Heisenberg, Pauli, Fermi, Dirac, Rutherford, and Kapitza, many of whom he knew personally. He arrived in Brazil in 1934, and after a few years started to send his best students to work under his European acquaintances. One of them, Mario Shenberg, worked with the Fermi group in Italy, and later with George Gamow in the United States. Another, Marcelo Damy de Souza Santos, after working with G. Ochiellini in Brazil, went to the University of Cambridge, where he worked on the measurement and detection of X-rays. Paulus A. Pompeia, an electronics engineer by training and Wathagin's assistant, went to the University of Chicago in 1940 to work under Arthur Compton, who had a joint project underway with Wathagin for the detection of cosmic rays. In 1946, Cesare Lattes went to work with Ochiellini in Cambridge and Oscar Sala went to work with M. Goldhaber at the University of Illinois.

When most of the European and North American high-energy physicists turned to research on nuclear energy during the war, the Brazilian group was left out. Those who had been abroad returned to

<sup>32</sup> See Rocha e Silva, Maurício, "Dez Anos pelo Progresso da Ciência", in *Revista Brasileira de Estudos Pedagógicos*, XXXIII, 77 (January-March 1960), pp. 221-234.

<sup>33</sup> For the development of the physical sciences in Brazil, see J. Costa Ribeiro, "A Física no Brasil", in Azevedo F. de, *op. cit.*, vol. I, pp. 203-242; and Pinto, Ricardo Guedes F., "Liliputianos e Lapucianos: Os Caminhos da Física no Brasil (1810 a 1945)" (Rio de Janeiro: Instituto Universitário de Pesquisas do Rio de Janeiro, unpublished M.A. dissertation, 1978).

São Paulo, and were soon asked to join the Brazilian war effort. The most interesting activity of the period was the development and production of sonars for the Brazilian navy, for the detection of German submarines. The United States already possessed the device but would not share it with Brazil at the time. The knowledge and skill developed by the physicists for the detection of high-energy particles as an academic activity proved to be an excellent basis for the mastery of sonar technology. After a period of trial and error, about 80 sonars were built in São Paulo by a collaboration of local suppliers and the ability in electronics of Damy and Pompeia. After the war, the demand ceased, and academics returned to their previous interests. The war had proved, to some Brazilians, that pure research could have important short-term practical results.

Research in nuclear and high energy physics continued after the war in São Paulo and Rio de Janeiro. Modern physics in Rio de Janeiro was initiated by Bernard Gross, a German physicist, a graduate of the University of Berlin who arrived in the country in 1933. Together with two Brazilians, Joaquim Costa Ribeiro and Francisco Oliveira Castro, he did some pioneering research in the field of solid state physics, and provided the basis for a small nucleus of research workers and teachers at the Instituto Nacional de Tecnologia founded in 1933 and the Faculdade de Filosofia of the Universidade do Brasil, which was established in 1939.

In 1949, a private research institution, the Centro Brasileiro de Pesquisas Físicas, was established in Rio de Janeiro. It brought together several scientists of high quality—Cesare Lattes, José Leite Lopes, Jayme Tiomno, Roberto Salmeron. In 1951 a governmental body to support science was created, the Conselho Nacional de Pesquisas. Both institutions were created by the personal efforts of Admiral Alvaro Alberto da Mota e Silva, a mathematician and physicist of some standing. The main concern of Alvaro Alberto, and the main purpose of these institutions, was to start nuclear research in Brazil, in a place which could be freed from the bureaucratic bonds of the university system and the civil service and, at the same time, receive financial support from the Conselho. In its constitution, the Conselho provided for a national commission on atomic energy—the Comissão de Energia Atômica—which, in 1955, became Brazil's first governmental agency concerned with questions of atomic research and engineering.

Despite these promising omens, the Centro de Pesquisas Físicas never really began to work in the field of atomic energy, and it fell victim to serious institutional problems after its first few years.

The original efforts of the research council to enter into research and development in atomic energy were only briefly supported during the second government of Vargas, 1950–54; the United States did not support these efforts because it wished to keep control over the enrichment pro-

cess. At the same time, the very weakness of the different centres dedicated to atomic research raises doubts as to whether they could have accomplished much of significance.<sup>34</sup>

In 1953 the Instituto de Pesquisas Radioativas was organised in Minas Gerais; since 1956 it has operated an experimental reactor of the Triga type using enriched uranium. In 1956 the much larger Instituto de Energia Atômica was organised within the University of São Paulo, with a 10 mw swimming pool reactor and about 1,000 research workers and technicians. In 1971 a 22 mw particle accelerator was installed. In 1954 the University of Rio de Janeiro started its first course in nuclear engineering, which graduated under 100 persons in the first 10 years. In 1965 it began the operation of its own experimental 10 kw reactor. In 1958 a group of physicists at the Instituto de Pesquisas Radioativas undertook to construct a nuclear reactor using thorium as fuel. In 1968 the project lost support from the federal government, when a decision was taken to build a full-scale atomic plant, with a Westinghouse model reactor using enriched uranium, to be provided by the United States.

The current programme for the production of nuclear power in association with the Federal Republic of Germany is conceived by those responsible for it as a purely industrial project, in which academic research has little place.

In short, research in advanced physics, which provided the basis for some applied research during the war, could not perform the same feat afterwards, in the much more complex and expensive field of nuclear technology. Confronted with the alternatives of developing technology invented or built by its own scientific community and the acquisition of foreign technology, the Brazilian government chose the second.

Once established but deprived of its main objective, the Conselho Nacional de Pesquisas became an agency which distributed its limited resources to individual scientists in the biological, physical, and other natural sciences. With its backing, independent research could develop in a few centres, even when the scientist's own university, usually more concerned with the problems of professional education or narrow short-term technical investigations, offered little support. Besides supporting research, the Conselho also provided, as it still does, fellowships for postgraduate and advanced studies abroad, in conjunction with the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (CAPES)

<sup>34</sup> For the national and international political aspects of nuclear physics in Brazil, see Guilherme, Olympio, *O Brasil na Era Atômica* (Rio de Janeiro: Vitória, 1957); Salles, Dagoberto, *Energia Atômica: Um Inquérito que Abalou o Brasil* (Rio de Janeiro: Fulgor, 1958); Carvalho, Hervásio G. de., "Pesquisa Básica e Desenvolvimento Nuclear", in Brasil, Câmara de Deputados, Comissão de Ciência e Tecnologia, *Ciência, Tecnologia e Desenvolvimento* (Brasília: Câmara de Deputados, 1973); Cerqueira Leite, Rogério C., *Energia Nuclear e Outras Mitologias* (São Paulo: Duas Cidades, 1977); Morel, Regina L. Moraes, *Considerações sobre a Política Científica do Brasil*, unpublished M.A. dissertation, Universidade de Brasília, Departamento de Sociologia, 1975; and Gall, N., *op. cit.*

an agency of the Ministry of Education, as well as foreign governments and agencies such as the United States Agency for International Development, the Ford Foundation, the Fulbright Commission, the British Council, the French government, and several others.

*1968: The Reform of the University*

In Brazil as elsewhere, 1968 was a year of intensive political agitation by students. At the end of the year, the authoritarian rule of the military government, which had been in power since 1964, became much stronger, with the enactment of the *Ato Institucional no. 5* and an extremely severe decree—the *decreto lei 477*—which forbade any kind of political demonstration by students. A profound reform in the Brazilian university system took place in 1968. The reform was carried out in a way which was connected with the repressive governmental policies prevailing over the past years, but it had a history of its own.

In 1961, an effort was made to build a modern university with a well-defined place for scientific research in the capital city of Brasília. The University of Brasília repeated the frustrated experience of the Universidade do Distrito Federal 25 years earlier. Some of its proponents like Anísio Teixeira and Darcy Ribeiro, who had been connected with the Instituto Nacional de Estudos Pedagógicos, the governmental agency which inherited the traditions and aspirations of the Associação Brasileira de Educação, had been associated with the earlier movement. The new university was built around central research institutes and teaching departments, like the universities of the United States, instead of the traditional combination of professional schools and independent chairs. It was meant to be a model university, and the professors who were invited to organise it participated in all aspects of its planning. Enthusiasm and hope were high. But the new university was too closely identified with the deposed government of João Goulart and in 1965 a conflict with the regime of Castelo Branco led to the resignation of most of its staff. That opportunity was lost.

In spite of its problems, the University of Brasília became the source of inspiration for another attempt to reform the Brazilian university system. It was first tried at the University of Minas Gerais and later generalised by law for the whole country after 1968. According to the new legislation, central institutes and departments were to be established in all universities, abrogating their traditional structure as federations of independent professional schools, and providing a place for research. A common basic course was created for broad areas of knowledge, thus postponing the students' decisions about their professional careers; entrance examinations for the universities ceased to be administered by each school and became unified for each geographical region and fields of knowledge, in an approximation of the French *baccalauréat*; the

courses ceased to be organised around a rigid succession of "years", and were replaced by a system of "course credits". At the same time, the universities lost their freedom to refuse unqualified students if they had places for them, and the number of university enrolments increased pronouncedly. Finally, graduate programmes on the North American model were to be created.<sup>35</sup>

The decision to open the gates of higher education to a much larger proportion of the applicants, without waiting for the effects of university reform, was carried on mostly through the new, separate and privately owned professional schools which were allowed to be created. From 1968 to 1969, first-year enrolment in these schools more than doubled, rising from 39,000 to 85,000. In consequence, in 1971 more than half of all Brazilian university students were enrolled in private institutions, compared to a third in 1964.

In the United States and some other countries, private universities are among the most distinguished in research and teaching. In Brazil, with a few exceptions such as the Mackenzie School of Engineering in São Paulo, or the Catholic University in Rio de Janeiro, the private institutions of higher education tend to be private enterprises intended to make a profit, with a maximum number of students for a minimum of investment in equipment and well-qualified teachers. The universities which are supported by the federal and state governments have the opportunity to attain fairly good standards of professional training. Because of this, families who can pay for pre-university training are able to send their offspring to the better institutions, which charge no fees, while the less well-off families have to pay for worse education.

This increase in admissions to universities was not accompanied by a corresponding enlargement of the teaching staff. The new private universities and professional school tended to provide courses in "soft" subjects, like law, social sciences, economics, and business administration, usually recruiting their staff indiscriminately, and having very poor facilities. At the same time, the public universities were flooded with applicants, many of them unqualified, who had to be accepted if there were places for them.

The expansion of the system of higher education has postponed the students' professional frustration for a few years. Instead of frustrating them at the point of entrance, the frustration now occurs after graduation from the professional schools. The combination of an enlarged undergraduate system with the concentration of talent and resources in the graduate and research programmes has led to a further deterioration

<sup>35</sup> Cunha, Luis Antonio, *Educação e Desenvolvimento Social* (Rio de Janeiro: Francisco Alves, 1975), esp. pp. 240-245; Brazil, Ministério da Educação e Cultura, *Reforma Universitária, Relatório do Grupo de Trabalho* (Rio de Janeiro: Ministério da Educação e Cultura, 1968); Florestan, Fernandes, *Universidade Brasileira: Reforma ou Revolução?* (São Paulo: Alfa-Omega, 1975).



of undergraduate teaching. For many professional careers, the master's degree has become a minimum condition for successful entry into the labour market. This has transformed the courses for this degree into extensions of undergraduate professional courses. Courses of study have in effect been extended by two to three years without any improvement in the quality of training. This has been particularly true in the new "semi-professions" such as economics, administration, psychology, but it is also becoming true of serious professions such as engineering and medicine.

In 1973, 67 per cent. of all students were enrolled in the social sciences, mainly in the newly created schools which provided an uncertain professional future. The majority of these students were enrolled in private institutions, which had less than 50 per cent. of the teachers in the country. In the natural sciences about 30,000 of the 46,000 were enrolled in courses of mathematics, and 63 per cent. of these were in private institutions. These mathematics students should not be placed together with those in technological subjects, but rather with the large numbers of students in literature, education, and social sciences, who can find employment after graduation only as teachers in secondary schools. The overwhelming majority of those studying for the medical and related professions are studying medicine (50,200) and odontology (14,500) (Table I).

The professional model for these students is the private practitioner in a system of private medicine. The demand for private medical service, which is very expensive, is however limited; of about 90,000 physicians in

TABLE I

*Undergraduate Enrolment in Brazil in 1973*

|                                                                            | Total<br>enrolment | Total<br>enrolment<br>% | Teachers<br>% | Students<br>in<br>private<br>institu-<br>tions<br>% | Places<br>available<br>in M.A.<br>pro-<br>grammes <sup>a</sup><br>% |
|----------------------------------------------------------------------------|--------------------|-------------------------|---------------|-----------------------------------------------------|---------------------------------------------------------------------|
| Education                                                                  | 67,700             | 10.4                    | 5.8           | 72                                                  | 4.1                                                                 |
| Natural sciences<br>(physics, mathe-<br>matics, chemistry,<br>geosciences) | 46,100             | 7.1                     | 15.9          | 53                                                  | 17.2                                                                |
| Biological<br>sciences (exclud-<br>ing medicine)                           | 12,000             | 1.8                     | 5.7           | 56                                                  | 8.4                                                                 |

TABLE I—continued

*Undergraduate Enrolment in Brazil in 1973*

|                                                                                                                                                                      | Total<br>enrolment | Total<br>enrolment<br>% | Teachers<br>%   | Students<br>in<br>private<br>institu-<br>tions<br>% | Places<br>available<br>in M.A.<br>pro-<br>grammes <sup>a</sup><br>% |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------|-------------------------|-----------------|-----------------------------------------------------|---------------------------------------------------------------------|
| Social sciences;<br>academic (socio-<br>logy, anthropo-<br>logy, history, geo-<br>graphy, philoso-<br>phy)                                                           | 46,000             | 7.1                     | 11.2            | 53                                                  | 11.2                                                                |
| Social sciences;<br>applied (law, ad-<br>ministration,<br>economics, library<br>science, commu-<br>nications psycho-<br>logy, architecture<br>and urban<br>sciences) | 248,900            | 38.4                    | 18.6            | 72                                                  | 15.0                                                                |
| Engineering                                                                                                                                                          | 58,300             | 9.0                     | 10.8            | 43                                                  | 19.5                                                                |
| Medical and re-<br>lated professions<br>(medicine, odon-<br>tology, pharmacy,<br>nutrition, nursing)                                                                 | 78,900             | 12.2                    | 18.2            | 35                                                  | 11.4                                                                |
| Agronomy and<br>veterinary science                                                                                                                                   | 18,600             | 2.9                     | 4.1             | 11                                                  | 4.6                                                                 |
| Language and<br>literature                                                                                                                                           | 71,400             | 11.0                    | 9.6             | 66                                                  | 8.5                                                                 |
| Total                                                                                                                                                                | 647,900            | 100                     | 100<br>(65,330) | 60                                                  | 100<br>(7,050)                                                      |

<sup>a</sup> The number of places offered for M.A. degrees is established by the universities according to the support they receive from the government for specific programmes; the physical and biological sciences and engineering are favoured by this arrangement.

SOURCE: Calculated from Brazil, Ministério da Educação e Cultura, *Plano Nacional de Pós-Graduação*. Figures for the last column are estimates presented in the plan.

Brazil at present, fewer than 10 per cent. are wholly in private practice and more than 30 per cent. combine private practice with salaried employment. Most of the country's health bill is covered by the Instituto

Nacional de Assistencia Medica e Previdencia Social, which transfers about two thirds of its revenues—about two billion dollars in 1976—to private medical service institutions. At the same time, there is no significant effort to train health professionals who could be employed in a more effective system of health care.<sup>36</sup>

### *The New Graduate Programmes*

The expansion of undergraduate enrolment, the creation of central research institutes at the universities, and the legal requirements of advanced degrees for promotion in academic careers, have led to an intensive effort of the Brazilian educational authorities to build a national system of graduate training on North American lines. Flooded by new and poorly trained students, entangled in the red tape and rigidity of the civil service, closely watched and infiltrated by security agents to observe students' and teachers' political attitudes, the professional schools have been regarded by many as hopeless institutions. The new graduate programmes, established very often in isolation from the undergraduate schools, appeared to be alternative places where some serious educational and research activities could be carried on: they started to command a growing amount of funds and to attract the best of the available talent in Brazilian higher education. This widened the difference between the standard of education available to the majority of students, and that available to the small proportion of the more fortunate who were in the few somewhat better institutions.

To stem the erosion in the quality of education, a law was passed which required that all teachers in higher educational institutions have at least a master's degree, and promotion was made dependent, among other things, on the possession of a doctorate.<sup>37</sup> Master's and doctoral degrees had not been awarded generally in Brazilian universities up to that time. The University of São Paulo, and to a lesser extent, other universities, followed the French pattern of granting a doctorate only after a long period of study and research. A doctoral dissertation usually followed, rather than preceded, establishment in an academic career. The new legislation looked to the American system, where there are organised programmes of courses leading to advanced degrees. In 1965, a joint commission was established between the United States Agency for International Development and the Brazilian Ministry of Education<sup>38</sup> to make a comprehensive evaluation and to offer recommendations about the

<sup>36</sup> "Médicos Ganham Menos que um Mestre-de-Obras do Metrô", *Jornal do Brasil* (16 July, 1978), p. 24.

<sup>37</sup> *Lei da Reforma Universitária*, No. 5.540, 28 November, 1968.

<sup>38</sup> Carneiro, J. F. D. et al., *Relatório da Equipe de Assessoria ao Planejamento do Ensino Superior (Acordo Ministério da Educação e Cultura—United States Agency of International Development)* (Rio de Janeiro: Ministério da Educação e Cultura, Diretoria de Ensino Superior, 1969).

reorganisation of the Brazilian university system. As new programmes began to take form, the educational authorities of the government, in order to limit the growth of inferior graduate programmes, created a complicated method of "accrediting" the new programmes. For example, one requirement was that a significant percentage of the staff of a newly created graduate programme have the doctorate.

Some consequences of this new structure of graduate training were that institutions and departments which had worked for years with a modicum of quality were suddenly flooded with students; they had to adapt to new bureaucratic procedures for accreditation and to compete for research funds with newly created programmes filled with foreign-trained scientists. Adaptation to the changed environment was often painful. Advanced degrees offered by Brazilian institutions lost prestige in comparison with foreign degrees; this led to resentment and frustration. At the same time, a large group of young bearers of M.A. and Ph.D. degrees were able to lay claim to governmental support for the establishment of new programmes, without regard to their actual academic potential.

The concentration of resources in the graduate programmes diverted most of the more talented teachers away from undergraduate courses. The combination of enlarged enrolments, the much wider range of social origins of the new generation of students, and the diversion of the best talents to graduate programmes, led to a substantial deterioration of most undergraduate education. An undergraduate university degree, which had been regarded as a professional qualification for its holder in Brazil, diminished in significance in the market place. This was particularly true outside the traditional professional schools of medicine and engineering, and even more so in new, "quasi-professions" such as business administration, psychology, education, and journalism. The consequence was that the programmes for the master's degrees, which were initially intended to improve the quality of the universities' staff and to stimulate research, became in many fields a necessary step for those wanting to enter the labour market for employment in the "quasi-professions". This, in turn, jeopardised the efforts to bring scientific and scholarly research into these graduate programmes.

The new graduate programmes were also jeopardised by the political climate after 1968. In 1969, several of the most talented Brazilian scientists in the natural and social sciences—José Leite Lopes, Mario Shenberg, Herman Lent, Roberto Salmeron, Fernando Henrique Cardoso, Florestan Fernandes, Aluisio Pimenta and several others—were forced into retirement from their teaching and research positions. They had been very active in the efforts to strengthen the country's scientific community and the social relevance of their work and were struck down by the

repression after 1968. Their exclusion made the new programmes suspect to many scientists and scholars who were reluctant to participate in programmes from which some of their more esteemed colleagues had been excluded.

### *Science and Technology for Development*

The authorities in the Ministry of Education were not the only ones dealing with graduate training. The main concern of the Ministry of Education has always been the undergraduate and the professional schools, which were directly under its supervision and administration. Support for the graduate programmes often came from other sources, sometimes foreign, such as the Ford Foundation and Agency for International Development in the fields of the social sciences and education, and from the Conselho Nacional de Pesquisas. In fact, since there was a considerable overlap between research and graduate training institutions, the Conselho undertook to support certain graduate training programmes on grounds of their intellectual merit.<sup>39</sup> As a result certain isolated groups of high quality within undistinguished universities had the chance to work and improve their quality in spite of the limitations of their parent institutions.

The involvement of Brazil's main investment bank, the government-owned Banco Nacional de Desenvolvimento Econômico, in the field of science and technology is the most important feature of the new period. For the first time in Brazilian history, there has been a concerted attempt to put science and technology at the service of economic development, through the application of a substantial amount of resources. In 1964 the bank established a programme for technological development known as the Fundo Nacional Tecnologia, which in its first 10 years, provided a total of about 100 million dollars for research and graduate training in engineering, the exact sciences and related fields.

The Fundo Nacional started with the idea that economic incentives could lead the private investors it supported to develop their own technology, instead of importing it from abroad; very soon it began to support selected teaching and research programmes. With the help of the Fundo Nacional, the University of São Paulo acquired its electrostatic accelerator, Pelletron, in 1971; a consortium of institutions started the development of a Brazilian mini-computer; the Centro Tecnológico

<sup>39</sup> Dr. Carl Djerassi, an American chemist who was very important in a joint programme in chemistry between the Brazilian Conselho Nacional de Pesquisas and the National Academy of Sciences of the United States suggested in 1968 a blueprint for the creation of "centres of excellence" in developing countries, which certainly had its influence in Brazil. See Djerassi, C., "A High Priority: Research Centers in Developing Nations", in *Bulletin of the Atomic Scientists*, XXIV (January 1968), pp. 22-27. See also Moreira, Manuel F. and Copeland, B. K., "International Cooperation in Science: Brazil-U.S. Chemistry Program" in *Interacias*, I, 3 (September-October 1976), pp. 138-145.

da Aeronáutica in São Paulo obtained support for its development of airplane engines; and the Instituto Militar de Engenharia in Rio de Janeiro was able to start its graduate programmes in several branches of engineering and chemistry. The most important achievement of the Fundo Nacional, however, was the creation of a complex system of graduate courses in engineering, the Coordenação de Programas de Pós-Graduação em Engenharia, at the Universidade Federal do Rio de Janeiro.<sup>40</sup>

This is the most ambitious graduate programme in engineering ever established in Latin America. It covers 11 fields of specialisation, including nuclear, systems, biomedical and chemical engineering, about 100 teachers and 1,500 graduate students. From 1964 to 1977, it granted about 1,000 master's and 25 doctoral degrees; most of the students have grants and tend to obtain employment even before they complete the dissertations needed for the master's degree. It has an extremely flexible programme, inviting foreign professors and sending their best students to study abroad, deciding on its own curriculum and research plans—things which are usually very difficult in Brazilian public universities. In its first years it kept very loose ties with the Universidade Federal do Rio de Janeiro and its school of engineering, and this has led to serious conflicts of authority and jurisdiction. In this sense, the Coordenação de Programas is very typical of a great number of the new Brazilian graduate programmes, established with independent resources on the margin of the main university system of graduate training, and having to rely on its ability to secure resources on a project-by-project basis.

The activities of the Fundo Nacional were later transferred to a new, specialised agency, Financiadora de Estudos e Projetos, which works as an investment bank for technological and feasibility studies at favourable rates of interest; it also administers a national fund for science and technology which, since 1964, has been part of the federal budget.

The entrance of the agencies of economic development and planning into the field of science and graduate training has increased the resources allocated to science and technology. It has also set a tendency to favour technological research rather than research in the basic sciences. Grants have to be negotiated every two or three years on a project-by-project basis, and the decision-making is in the hands of economists and administrators.

A national plan for science and technology was promulgated in 1973, and again in 1975, as the Banco Nacional de Desenvolvimento Econômico, the Financiadora de Estudos e Projetos and, after 1975, the Conselho Nacional de Pesquisas, came under the authority of the ministry of planning (Table II).

<sup>40</sup> Banco Nacional de Desenvolvimento Econômico, *FUNTEC: 10 Anos de Apoio a Pesquisa* (Rio de Janeiro: Banco Nacional de Desenvolvimento Econômico, 1974).

TABLE II

*Planned Expenditures for Research and Development*  
(percentage of resource allocations)

|                                                                                        | <i>1st Plan (I)</i> |       | <i>2nd Plan (II)</i> |       |       |
|----------------------------------------------------------------------------------------|---------------------|-------|----------------------|-------|-------|
|                                                                                        | 1973                | 1974  | 1975                 | 1976  | 1977  |
| Atomic energy                                                                          | 9.0                 | 9.7   | 5.4                  | 6.3   | 7.0   |
| Other technology: space, marine research, non-conventional sources of energy (II)      | 6.5                 | 7.3   | 4.7                  | 4.5   | 3.5   |
| Technology of infra-structure: electric energy, oil, transportation, communications    | 9.9                 | 9.5   | 12.2                 | 14.0  | 13.9  |
| Industrial technology                                                                  | 28.0                | 28.8  | 20.8                 | 19.4  | 20.0  |
| Agricultural research: agriculture, cattle-raising, forestry, fishing, meteorology (I) | 10.8                | 11.4  | 12.3                 | 13.6  | 14.8  |
| Technology for social and regional development                                         | 4.7                 | 4.8   | 8.5                  | 6.7   | 6.9   |
| Scientific development; development of scientific personnel, graduate training         | 22.3                | 21.0  | 27.3                 | 26.2  | 25.6  |
| Others                                                                                 | 8.1                 | 7.5   | 8.9                  | 9.1   | 8.2   |
| Absolute value in millions of \$ US                                                    | 323.4               | 379.4 | 680.0                | 767.1 | 824.8 |

SOURCE: Brazil, Secretaria de Planejamento (*I and II Plano Nacional de Desenvolvimento Científico e Tecnológico* (Brasília: Secretaria de Planejamento, da Presidência da República, 1973 and 1975). Dollar values are estimated using 1975 as a basis, when Cr\$ 10,00 = US\$ 1.00. Corrected for Cruzeiro, not dollar, inflation.

For the period 1973-74, 65 per cent. of the planned expenditures were made by ministries and other federal agencies over which the Ministry of Planning did not have direct influence. Twenty-three per cent. was in the hands of agencies such as the Banco Nacional de Desenvolvimento, the Financiadora de Estudos e Projetos and the Conselho Nacional de Pesquisas. Less than 5 per cent. seems to come from foreign sources. For the second period, to cover the years from 1975 to 1977, the percentage in the hands of independent ministries was reduced to 44 per cent., while the amount to be handled by the planning agencies increased to 32

per cent. Foreign sources were still below 5 per cent. Between the first and the second plan, the amount of resources to be handled by the planning agencies went from \$61 to \$219 millions, which corresponds to the increase from 23 per cent. to 32 per cent. of their share of the total resources for research and development.

There has been a tendency to reduce support for scattered projects in industrial research and to concentrate on scientific training and university research, research projects in the areas of "infrastructure" and agricultural research. There has also been an increase in resources allocated to problems directly related to social conditions. Finally, the average rate of growth in planned expenditures on research over the five year period is about 26 per cent. annually, which is more than twice the general growth rate of Brazil in the early 1970s.

In 1975, the Conselho Nacional de Pesquisas became the Conselho Nacional de Desenvolvimento Científico e Tecnológico, under the Ministry of Planning. At the same time, it was granted financial and administrative autonomy to appoint its own staff and to make its own decision regarding expenditures. The Conselho became responsible for co-ordinating, planning and supervising the country's scientific and technological policy.

#### *Present Dilemmas*

The so-called "Brazilian miracle" of the early 1970s had evaporated by 1975-77, and in these years the increase of resources, persons, and institutions in scientific research and higher education in Brazil also began to slow down.

The bodies which were responsible for the fixed costs of the most expensive research and training programmes in the country had little left over to initiate new projects, since their resources had ceased to expand. Choices became more pressing. Committees to concert policies among the various bodies were established and uniform standards for fellowships, grants, and the assessment of programmes were worked out. One of the results was more bureaucracy, fewer bold projects, less flexibility, but also more stability of income. A stop was placed on the creation of new undergraduate courses, while some attempts were made to improve existing ones.

In retrospect, the recent expansion of science, technology, and higher education in Brazil stems from a combination of several interrelated trends: an increasing demand for professional university degrees, an increasingly demanding scientific community, and more involvement of agencies of economic planning in the field of science and technology. With each of these trends are associated different institutions, persons, and outlooks. They are not necessarily compatible; they often clash with each other. Scientific development in Brazil is hindered by the lack of a consistent economic policy regarding the use of technological resources, by



the problems besetting an inflated undergraduate student body in the universities concerned with entry into the new "quasi-professions", by the generally limited power and stability of the scientific community and by its weakness in the face of governmental authorities in education, science and technology.

Given the sheer size of the country's scientific and educational establishment as well as the continuous debate about the proper ways in which the scientific and technological activities should be organised and directed, the present situation is much more complex than before. It would be illusory to try to find a more elaborate and comprehensive policy behind the recent developments. In fact, the relative abundance of resources has permitted governmental agencies to act independently, without any insistence from above that they concert their policies.

This has led to a healthy diversity and plurality which may be reduced as resources become more scarce and the planning agencies increase their power. This does not mean, of course, that the present situation is satisfactory.

There have been several effects of this situation on the Brazilian scientific community. With the new programmes, came more resources and facilities for graduate training and scientific research. A distinction between research and professional degrees was never officially introduced, and scientists often tried to lead students seeking a few more years of professional training into scientific work, with frustrations on both sides. This situation became particularly serious because the best scientists were called to teach in the graduate programmes. The deterioration of undergraduate programmes also made the recruitment of new talent for scientific careers very difficult. In the 1930s and 1940s, the secondary schools would often be the places where young persons were inspired to seek careers in science. Now, it is likely that only at the stage of study for the master's degree will a student be exposed to a challenging environment. There is a common complaint among those involved in graduate training that they find it more and more difficult to find properly motivated and reasonably trained pupils for their programmes. Nonetheless, the active presence of the scientific community in undergraduate activities seems to be the only way to attempt to improve the universities.

This situation is made still more difficult by the fact that, historically, science was not a career normally chosen by the children of the Brazilian upper classes, or the most ambitious of the lower and middle classes. Brazilian scientists, more often than not, came from immigrant and scattered intellectual families; these never added up to anything like the scientific movements which other countries had experienced. In the biomedical sciences, proximity to a traditional profession, medicine, provided research with some social support, but it also had the drawback of

a lack of independence. In other fields, scientists tended to be viewed by the Brazilian elite as a group of middle-class, sometimes foreign-born intellectuals who had esoteric interests and who demanded too much support and too many privileges. The political and administrative elites wanted the benefits of technology, and had some notion that, to achieve this, science should be supported. This was seldom accompanied by any clear understanding of what scientific activity is.

The recent efforts to bring science and education together with technology under a system of comprehensive planning has caused much frustration and bitterness to many scientists concerned with their own scientific work. The new Conselho Nacional de Desenvolvimento Científico e Tecnológico is several times larger than its predecessor, the Conselho Nacional de Pesquisas, and is only one in a host of new institutions, commissions and grant-awarding bodies. The establishment of plans for scientific, technological and educational development has generated very complex systems of evaluation, which create large amounts of paperwork and much delay. Scientists are often involved in these activities as advisers, members of review boards and consultants; final decisions, however, are taken by civil servants and politicians who seldom justify their decisions in public. All this is seen by many scientists as expensive, unnecessary and inefficient, in contrast with São Paulo's Fundação de Amparo à Pesquisa, where all the decisions are taken by a scientist working with a very small administrative staff, and fully exposed to the scrutiny of the scientific community.

In developed countries, the larger part of the resources for scientific and technological research is spent on its application; in the developing countries, the opposite seems to be the rule.<sup>41</sup> Brazilian plans for science and technology seem to show that there is an attempt to approach the pattern of expenditures of the developed countries. There is so far no clear evidence, however, that these efforts to develop applied knowledge and bring it to industry are actually producing any substantial benefits.

Brazilian industrial firms, public and private, have usually shown little interest in research and development. There is a good economic reason for that: it is normally cheaper to license or import well-developed technology abroad than to try to develop it at home. Foreign technology is already developed and tested, and can be relied upon. The Brazilian pattern of economic growth has always emphasised the free admission of foreign capital, enterprises and technology. This pattern not only makes it easy to import well-developed processes and equipment, it makes it essential for survival in the market place. Given this situation, it is reasonable to ask whether all the effort to develop indigenous Brazilian technology in industry is not being wasted.

<sup>41</sup> Data on resource allocation for basic and applied science in developing countries are difficult to obtain. See Moravcsik, Michael J., *Science Development* (Bloomington, Indiana: PASITAM, 1975), p. 108.

An implicit assumption of many investments in technology is that, if good products and processes can be obtained, they will somehow become socially or economically beneficial. The experience seems to have shown that this is not always the case. Technological research within a university or a research institute is relatively inexpensive and inconsequential. The adoption of a product in the market place is an altogether different matter. There are many examples. It is possible to produce milk from soyabeans, which is as nutritious as and cheaper than natural milk. However, to bring this synthetic milk to the market entails confrontation with the dairy farmers who would oppose it. Brazil could develop a significant pharmaceutical industry based on indigenous skill and natural products; this would require, however, their ability to compete successfully with multinational firms which are preponderant in that industry.<sup>42</sup> The technology for the substitution of gasoline by sugar cane alcohol is well established. There are however some serious obstacles; for instance, sometimes the export value of sugar is higher than the market value of alcohol; there is the problem of adapting the cars to the use of alcohol, which is not easily done.<sup>43</sup>

The attempt to build an indigenous technology in a country has therefore to work against the economies of the market which points to the uneconomic character of indigenous substitutes for foreign technology and its products.

What is sought, however, is not scientific and technological self-sufficiency, but the capacity to make important economic and technological decisions within the country.

A country has its own technology when its institutions and industries are able to select technologies developed in the industrialized countries, add to them new ingredients and use them to solve in the best possible way the country's problems. Not even the more advanced countries can pass without the absorption of foreign technologies. What characterizes a technologically independent country is its ability to take its own decision about which ingredients of its productive system should be imported from abroad and which should be developed originally. This ability requires, of course, the existence of a creative capacity within the country.<sup>44</sup>

In this sense, the presence of competent technologists and some reservoir of technical expertise might open up alternatives which would not exist otherwise. For instance, a recent decision to protect the market for

<sup>42</sup> See Bertero, Carlos O., *Drugs and Dependency in Brazil: An Empirical Study of Dependency Theory: The Case of the Pharmaceutical Industry*, Latin American Studies Program Dissertation Series no. 36 (Ithaca: Cornell University), 1972; and Evans, Peter, "Foreign Investments and Industrial Transformation", *Journal of Development Economics* III, 4 (Summer 1975), pp. 121-140.

<sup>43</sup> On the problems of alternative sources of energy, see Goldemberg, Jacob, "Brazil: Energy Options and Current Outlook", *Science*, CC, 4338 (14 April, 1978), pp. 158-163. See also Hammond, Allen L., "Alcohol: A Brazilian Answer to the Energy Crisis", *Science*, CXCIV, 4278 (11 February, 1977), pp. 565-567.

<sup>44</sup> Pereira da Costa, Alberto, "Desenvolvimento Tecnológico do Brasil", in Academia de Ciências do Estado de São Paulo, *Anais do Primeiro Simpósio Anual* (São Paulo Academia de Ciências do Estado de São Paulo, 1976), pp. 33-53.

mini-computers for Brazilian firms would not have been possible without several years of previous investment in the development of experimental computers at the University of São Paulo and the Catholic University of Rio de Janeiro. Alternative energy policies could eventually derive from the availability of new or adapted forms of non-conventional sources of energy, such as the sun, the wind, and sugar cane alcohol; this is attracting many research groups in different parts of the country. The development of scientific and technological staffs at the universities might lead to the creation of institutional bridges between academic research centres and industry; they could train scientists and engineers who might improve the quality of those who go into industry, regardless of what is done with the results of the research which they do while they are being trained at university.

The problems to be solved by indigenous technology are approached with many considerations in mind, such as short-term economic gains, national pride, employment for technologists, creation of demand for suppliers of parts, and developing skills and technological self-confidence.<sup>45</sup> Political motives strengthen the desire to keep within the country all aspects of technology which are important for national security and independence—including communications, energy, computers and military equipment. Economic considerations are usually long-range and roundabout; they are based on the hope that, in the long run, the costs of technological licensing are higher than the costs of technological self-sufficiency since the former implies a continuous flow of payments for research and development abroad, which could be used for investment and employment at home.

These social and political considerations are based on the views that market mechanisms cannot bring an underdeveloped country to a state of satisfactory economic development and social justice. Foreign firms which operate in underdeveloped economies usually come with their technologies fully developed in the advanced countries and train their workers only in routine procedures of operation and maintenance. Indigenous firms prefer to buy demonstrated machines and processes abroad, which usually include contracts covering replacements and technical assistance. Imported technology is also usually labour-saving, and produces sophisticated goods for the wealthier classes, leaving large sectors of the population without provision.

The solutions to these problems are not obvious. Policies which aim at technological self-reliance easily lead to the protection of inefficient industries, to the maintenance of expansive, unproductive and poor research, and to the growth of costly and sluggish bureaucracies.<sup>46</sup>

<sup>45</sup> Erber, Fabio S., "Technological Development and State Intervention: A Study of the Brazilian Capital Goods Industry" (University of Sussex, unpublished Ph.D. dissertation, 1977).

<sup>46</sup> Bauer, Peter, "Reflections on Western Technology and 'Third World' Development", *Minerva* XV, 2 (Summer 1977), pp. 144-154.

One criticism of Brazil's recent expansion of research and technology is that it is a policy of subsidy for one group of intellectuals. The high salaries paid, the facilities for travel abroad, the use of English as a language for publication, the preference the scientists have for research instead of teaching, the preference of many for research which is more intellectually attractive, while disregarding the useful and practical, call forth bitter criticism. The critics say that if the country does not follow proper political and social policies, the development of its scientific and technological capacity can only reinforce the present patterns of underdevelopment and economic dependence.<sup>47</sup>

### *Conclusions*

It is clear that the decisions taken in a country about its scientific, technological and educational policies are influenced by the vested interests of its scientific and educational communities, as well as by the various social groups which have interests in these matters and the means to advance them. In the authoritarian regimes which have prevailed in Brazil in the last 14 years, it was possible to restrict the range of participation in the exercise of power. This freedom has often been exercised to the benefit of very limited private groups and institutions which have close ties with the higher circles of government and administration.

The problems of Brazilian science, technology and higher education are no different from most other problems of economic and institutional development in authoritarian regimes. The promotion of science, technology and education is in many important respects a political problem. But the problem is not soluble simply by political freedom. In the past, the general concern for practical results has led to a strictly utilitarian view of science and technology, and a disregard of the need to create a much stronger and well-established educational system, which would give to the scientific community more coherence, continuity, and influence than it has at present.

This has been a constant feature of the Brazilian history; it is not unique to the most recent period. It is possible, however, that the growth of the recent years has given to Brazilian scientists and technologists the strength to thrive in a more competitive and demanding environment than what they had so far. It is an opportunity that should not be neglected.

<sup>47</sup> For two recent examples, see the interviews given by Luis Hildebrando Pereira da Silva (a biologist who is the head of the parasitology department of the Institut Pasteur) to the magazine *Isto É*, 55 (11 January, 1978) and José Leite Lopes, a physicist who heads the division of high energy physics at the Centre de recherches nucléaires, Strasbourg, to *Impact of Science on Society*, XXVII, 3 (July–September 1977). For this view that modern technology can be a liability for a developing country, see Wade, Nicholas, "Third World: Science and Technology Contribute Feebly to Development", *Science*, CLXXXIX, 4205 (5 September, 1975), pp. 770–771, 774–776.